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## Jelutong.

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### Introductory.

An account was given in a previous number of the Journal, Vol. XVI, 1928, No. 5, page 204 of an investigation regarding the effect of the addition of certain metallic salts to jelutong in various stages of its preparation.

It was shown that while the effect of the addition of soluble iron and copper salts to the latex before coagulation was to cause oxidation of the product the addition of manganese appeared to favour mould development.

Owing to the fact that jelutong can become so easily contaminated with iron during its preparation a comprehensive series of experiments has been carried out in order to ascertain the stage at which iron has the greatest effect.

The experiments with copper and manganese salts have also been repeated for the purpose of confirming the preliminary observations.

With regard to the alleged increased tendency of Kedah jelutong to oxidation another visit has been made to the Jeniang concession for the purpose of carrying out further experiments with the fresh latex.

In addition, an investigation has been carried out regarding the storage qualities of jelutong in a creped form

in view of the contention that the material in this state is particularly liable to oxidation.

It may be of interest to mention that this point arose during the course of the investigation on the valuation of the material, a record of which was published in this Journal, Vol. XVI, 1928, No. 6, page 220. With the large number of blocks being tested for moisture content there was a considerable amount of surplus jelutong which it was decided to ship to New York. Reports were received, however, that on arrival the material was practically valueless owing to oxidation during transit. In view of the investigation being carried out at the time on the general question of deterioration due to oxidation the information was considered of sufficient importance to warrant carrying out further experiments on the storage qualities of creped jelutong by measuring the increase in the amount of the acetone soluble content of the material at monthly intervals.

### 1. The Addition of Metallic Salts.

(a) *The addition of soluble iron salts to latex before coagulation by standing.*—Duplicate blocks of jelutong were prepared by mixing 100 ccs of local latex with varying amounts of an 8.6 per cent solution of ammonium iron alum (1 cc. is equivalent to 0.01 grammes of iron) and coagulating with 0.2 ccs of 10 per cent sulphuric acid. Control experiments with sulphuric acid alone were also carried out.

Sulphuric acid was employed in preference to acetic acid, since experiments have shown that during the wet season sulphuric acid is a more reliable coagulant than acetic acid as regards degree of coagulation and further many producers use sulphuric acid regularly as a coagulant for their latex.

The coagula were removed after four days and the excess serum squeezed out by hand. In one series of experiments the blocks of crude jelutong were allowed to drain for two days and weighed, while in the other the coagula were refined by treatment with boiling water, the resultant blocks being also allowed to drain for two days and weighed.

Both sets of blocks were examined from time to time for signs of oxidation and when a block became so brittle that it broke on handling the material was ignited and the iron estimated.

The final examination of the blocks was made after four months.

The results of the experiments with the crude product, summarised in Table I, show that soluble iron salts present in the latex in very small proportions induce oxidation with relatively great rapidity and without any development of mould, also before any considerable reduction in the weight of the block has occurred owing to loss of moisture. This is all the more surprising since previous experiments have shown and confirmation has been obtained in the present series that with sulphuric acid as a coagulant the crude coagulum develops mould rapidly on storage.

It is interesting therefore to record that the presence of an amount of soluble iron equivalent to 1 part in 20,000 parts of latex causes the crude material to oxidise completely in approximately three months, the total iron present in the oxidised material being equivalent to only 60 per cent of the amount originally added.

Further, although the figures in the table show that between 45 and 60 per cent of the amount of iron added to the latex is present in the coagulum this amount of iron includes that present in the serum in the block. The amount of iron associated with the jelutong will be therefore considerably less than that found for the whole block. Assuming that the amount of serum in each block is approximately 20 ccs it will be seen that the estimated amounts of iron associated with the jelutong vary from 0.010—0.002 grammes.

With regard to the material refined by boiling with water none of the blocks became completely brittle, although as will be seen from Table II several showed considerable signs of deterioration due to oxidation after storage for four months. There is little doubt therefore that treatment with boiling water increases both the toughness of the material and its resistance to oxidation.

## TABLE I.

*Results of Experiments with the Crude Coagulum.*

| Volume of latex. ccs. | Amount of iron added grammes. | Equivalent volume of latex per gramme weight of metal. ccs. | Weight of fresh block. grammes. | Weight of block when analysed. grammes. | Loss in weight on storage. grammes. | Approximate period of storage for complete oxidation. weeks. | Amount of iron present in oxidised material including serum. grammes. | Proportion of original amount of iron added. per cent. | Estimated amount of iron present in oxidised material grammes. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| 100 | .040 | 2,500 | 37.0 | 29.5 | 7.5 | 8 | .018 | 45 | .010 | Material completely oxidised. |
| 100 | .020 | 5,000 | 38.5 | 29.5 | 9.0 | 9 | .010 | 50 | .006 | Material completely oxidised. |
| 100 | .010 | 10,000 | 40.0 | 28.0 | 12.0 | 10 | .005 | 50 | .003 | Material completely oxidised. |
| 100 | .005 | 20,000 | 40.0 | 23.5 | 16.5 | 12 | .003 | 60 | .002 | Material completely oxidised. |
| 100 | .002 | 50,000 | 37.5 | 25.0 | 12.5 | | | | | Development of black mould with specks of oxidised material. |
| 100 | .001 | 100,000 | 38.0 | 26.0 | 12.0 | | | | | Development of black mould. |
| 100 | Nil | Nil | 41.3 | 27.0 | 14.3 | | | | | Development of black mould. |

## TABLE II.

*Results of Experiments with the Refined Coagulum.*

| Volume of latex. ccs. | Amount of iron added. grammes. | Equivalent volume of latex per gramme weight of metal. ccs. | Weight of fresh block. grammes. | Weight of block when analysed. grammes. | Loss in weight on storage (4 months) grammes. | Amount of iron present in stored material. grammes. | Proportion of original amount of iron added. per cent. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 100 | .040 | 2,500 | 39.6 | 35.2 | 4.4 | .010 | 25 | Outer layers of block oxidised to a depth of $\frac{1}{4}$ inch. |
| 100 | .020 | 5,000 | 39.6 | 33.9 | 5.7 | .004 | 20 | Outer layers of block oxidised to a depth of approximately $\frac{1}{8}$ inch. |
| 100 | .010 | 10,000 | 41.4 | 34.8 | 6.6 | .003 | 30 | Outer layer could be flaked off. |
| 100 | .005 | 20,000 | 41.9 | 36.6 | 5.3 | .002 | 40 | Outer layer commencing to flake. |
| 100 | .002 | 50,000 | 41.7 | 35.5 | 6.2 | .001 | 50 | Satisfactory. |
| 100 | .001 | 100,000 | 42.8 | 37.8 | 5.0 | Traces | | Satisfactory. |
| 100 | Nil | Nil | 40.0 | 33.0 | 7.0 | | | Satisfactory. |

Compared with the corresponding blocks in the first series a reduction in the iron content will be noticed in every case. This is, however, only to be expected since the effect of boiling with water is to eliminate the soluble iron present in the serum, the material retaining probably only the iron associated with the jelutong on coagulation. In this connection it is interesting to note the relatively close agreement between the estimated amounts of iron associated with the jelutong in the case of the crude material and the amounts determined for the refined material.

Confirmatory results were obtained from experiments in which acetic acid was used as the coagulant and soluble iron was added both as ferric chloride and ammonium iron alum. For example, in one series in which acetic acid was used as the coagulant and soluble iron in the form of ferric chloride was added to the latex in the proportion of one part of iron to 5,000 parts of latex the crude material was completely brittle after two months storage, the iron present in the jelutong being approximately 40 per cent of the amount originally added.

Further, in another series of experiments in which acetic acid was used for coagulation and amounts of soluble iron in the form of ammonium iron alum were added to the latex in the proportions of one part of iron to 2,500 and 5,000 parts of latex respectively and the material refined by boiling with water, the blocks were completely brittle after 3 months and 4 months respectively. In both cases only approximately 33 per cent of the iron originally added was present in the oxidised material.

*(b) The addition of soluble iron salts to latex before coagulation by boiling.*—Similar series of experiments in which the jelutong was coagulated by boiling showed that the product was still susceptible to oxidation, even though the material was subsequently refined by boiling with water.

Thus, in a series of experiments in which acetic acid was used as a coagulant and soluble iron in the form of ferric chloride was added in the proportion of one part of iron to 5,000 parts of latex the material coagulated by boiling was completely oxidised after 4 months, while refining the jelutong by boiling with water resulted in the product holding up for an extra month before becoming brittle. The iron present in the material was in both cases equivalent to only approximately 35 per cent of the amount originally added.

In another series in which acetic acid was also used as the coagulant and soluble iron in the form of ammonium iron alum added in the proportion of one part of iron to 5,000 parts of latex, the jelutong being coagulated by boiling and refined by boiling with water, the material was completely oxidised after four months. Only approximately 35 per cent of the iron originally added was present in the oxidised material.

(c) *The coagulation of latex in rusty tins.*—Duplicate experiments were carried out in which jelutong latex was coagulated with sulphuric acid in both rusty and clean tins. The coagula were removed after four days, the serum being squeezed out by hand. In one experiment the blocks were allowed to drain and stored, while in the other the blocks were refined by treatment with boiling water previous to storage.

In the case of the crude blocks deterioration due to black mould quickly developed and although there were specks of what appeared to be oxidised material they were difficult to identify in the mouldy mass. With the refined blocks deterioration due to oxidation was more marked, since on examining the blocks it was noticed that a spot of rust was invariably surrounded by oxidised material.

(d) *The addition of insoluble iron to latex before coagulation by standing.*—Duplicate blocks of jelutong were prepared by mixing small quantities of very finely ground ignited iron oxide with latex before coagulation by standing, sulphuric acid being used as the coagulant. The amounts of iron added were equivalent to approximately one part in 7,500 and 15,000 parts of latex respectively.

The coagula were removed after the usual period, the excess serum squeezed out by hand and the blocks stored. In both cases deterioration due to black mould developed, the material showing no signs of oxidation although the particles of iron oxide were distributed throughout the blocks.

(e) *The addition of insoluble iron to latex before coagulation by boiling.*—Duplicate blocks of jelutong were prepared as in the previous series of experiments except that the material was coagulated by boiling. In this case also no deterioration of the material due to oxidation took place, even though the material was stored for four months.

(f) *The storage of the crude coagulum in water containing iron.*—Since it has been suggested that deterioration due to oxidation may be due to the jelutong absorbing iron from water in which it may be stored prior to refining a series of experiments was carried out in which the crude coagulum was soaked in water to which varying amounts of a suspension of ferric hydroxide in water had been added. The ferric hydroxide had previously been washed free from salts, and when shaken up with water some of the precipitate appeared to become colloidal so that the conditions as regards possible absorption of iron were as favourable as possible.

The concentrations employed varied from 40 parts to 1 part of iron in 100,000 parts of water. The liquid was stirred constantly each day in order to prevent the precipitate from protecting the coagulum. The blocks remained soaking for four days, after which they were refined by treatment with boiling water and stored.

The blocks showed no signs of deterioration due to oxidation after storage for four months even though in the case of the higher concentrations the material was brown in colour from contact with the ferric hydroxide.

(g) *The refining of jelutong by boiling in water containing iron in suspension.*—A similar series of experiments was carried out in which the crude coagulum after being soaked in clean water for two days was boiled in water to which varying amounts of ferric hydroxide had been added, the concentrations varying as indicated in the previous series

The blocks showed no signs of oxidation after four months storage, even though as in the previous series some of the blocks were brown in colour.

(h) *The surface treatment of the crude and refined coagulum with both soluble and insoluble iron.*—Duplicate blocks of material were prepared by coagulating latex with acetic acid, both by standing and boiling. When the blocks were shaped small depressions were made so that drops of liquid placed on the blocks would evaporate on the surface.

The blocks were allowed to dry for two days after which they were treated with drops of the following (a) 2 per cent solution of ferric chloride (b) 1 per cent solution of ferric

chloride (c) 8.6 per cent solution of ammonium iron alum (d) 4.3 per cent solution of ammonium iron alum (e) suspension of ferric hydroxide in water, while other blocks were pierced with rusty nails. The blocks were then stored for four months.

In the case of the jelutong coagulated by standing, none of the blocks showed any signs of deterioration due to oxidation, although all were affected by mould development. One or two blocks prepared by coagulating the latex by boiling showed signs of deterioration due to oxidation where the drop had been applied, but there was no tendency for the oxidation to spread.

(j) *The addition of copper salts to latex before coagulation by standing.*—Duplicate blocks of jelutong were prepared by mixing 100 ccs of local latex with amounts of copper sulphate equivalent to 1 part of copper to 2,500, 3,300, 5,000 and 10,000 parts of latex respectively and coagulating with 0.5 ccs of 10 per cent acetic acid. Control experiments with acetic acid alone were also carried out.

The coagula were removed after four days and the excess serum squeezed out by hand. In one series of experiments the blocks of crude jelutong were stored, while in the other the coagula were refined by treatment with boiling water before storage.

In the case of crude material there was no deterioration due to oxidation and with the exception of the control there was only evidence of deterioration due to development of mould in the case of the block in which the latex had been treated with copper in the proportion of 1 part to 10,000 parts of latex. None of the blocks of refined material showed any signs of deterioration due to oxidation.

(k) *The addition of copper salts to latex before coagulation by boiling.*—A similar series of experiments to the above was carried out in which the latex was coagulated by boiling, acetic acid being used as the coagulant. It is interesting to note that an increase in the proportion of copper results in a decrease in the degree of coagulation.

After four months storage it was noticed that in the case of the blocks prepared from latex to which copper in the proportions of one part to 2,500 and 3,300 parts of latex had been

added before coagulation the material was completely oxidised. With the lower concentrations of copper there was a tendency for the material to break short, especially after refining treatment with boiling water.

(1) *The addition of manganese salts to latex before coagulation by standing.*—Blocks of jelutong were prepared by mixing 100 ccs of local latex with amounts of manganese sulphate and manganese chloride equivalent to 1 part of manganese to 1,000, 2,000 and 4,000 parts of latex and coagulating with 0.5 ccs of acetic acid. A control experiment was carried out in which the same amount of latex was coagulated with acetic acid. It was noticed that the addition of manganese, especially in the higher proportions, inhibited coagulation.

The coagula were removed after four days and the excess serum squeezed out by hand. The blocks of crude jelutong were then stored.

The blocks were examined from time to time for mould development. Although in the case of those blocks in which manganese salts had been added to the latex an external stickiness of the block developed more rapidly than in the case of the controls, the final results did not indicate that the addition of manganese is associated with an abnormal mould development.

## Remarks and Conclusions.

In general, the results may be said to confirm those obtained in the previous investigation.

It is clearly shown that of the three metals iron is of paramount importance as regards the development of deterioration due to oxidation and further that this metal has the greatest effect when present in a soluble form in the latex before coagulation. The addition of this metal in either an insoluble or a soluble form at a later stage in the preparation of the product appears to be without effect.

The experiments indicate that the amount of soluble iron affecting jelutong is so small as to suggest the possibility of some catalytic reaction when the material is exposed to air and, if a general improvement in the standard of Malayan jelutong as regards this particular form of deterioration is to

be effected, it will be essential to impress on all producers the necessity of eliminating this metal in a soluble form from the latex before coagulation.

In this connection it is considered advisable therefore to repeat the conditions necessary for the preparation of high quality material, the straining of the latex before coagulation, the employment of clean vessels for coagulation and the use of pure coagulants.

With regard to the preliminary straining of the latex it is of interest to note that the largest American purchaser of Malayan jelutong is already insisting on a modicum of cleanliness as regards adventitious matter, although in the writer's opinion clean coagulating vessels and pure coagulants are of much greater importance.

Our experiments have shown that badly rusted tins may result in local oxidation, but one of the more important sources of contamination undoubtedly lies in the employment of wooden boxes for coagulation, the boxes being made watertight by filling the interstices with clay. It is well known that Malayan clays contain iron in varying proportions, some of which is certain to pass into solution during coagulation in an acid medium.

Further, the large amount of unnecessary secrecy regarding the nature of the coagulant may be responsible for a certain amount of deterioration. Unless producers purchase chemicals free from iron and prepare their coagulant under conditions which do not allow of iron being dissolved in the acid medium it is quite likely that in their desire to keep the details of their coagulant a secret they may be introducing iron, at the same time being ignorant of its ultimate effect on the product.

It may be contended that there are other causes responsible for deterioration due to oxidation and that too much insistence is laid on the presence of iron, especially when it will be seen later that the presence of iron in the ash from jelutong does not necessarily indicate that the material is oxidised. Against this it may be mentioned that jelutong latex gives only a faint oxidase reaction and that it was not until soluble iron was added to the latex before coagulation that deterioration due to oxidation was ever obtained in material prepared in the Department, even though blocks have been stored for nearly three years.

Further, although the Forest Department have been producing jelutong on a commercial scale for nearly three years no report has ever been received regarding the oxidation of their product, the high quality of which is undoubtedly due to the adoption of the precautions outlined above.

A previous article on this subject in this Journal, Vol. XV, 1927, No. 11, page 404 contained a statement that jelutong latex from local forest reserves was unlikely to be affected by oxidation, since experiments had shown that the only type of deterioration affecting the material was development of mould in the crude product and that this could be controlled by treatment with boiling water. As stated above, it was not until soluble iron was added to the latex before coagulation that deterioration due to oxidation was ever obtained in material prepared in the Department and since it has also been shown that soluble iron can be introduced so easily into the latex in a proportion that will affect the resultant product these are considered sufficient grounds for maintaining that iron is one of the most important causes of oxidation.

At present there is no simple method of detecting the active iron in a block of fresh material. It is true that a test has been suggested in which the freshly-broken surface of a block is treated with a drop of acid and a drop of a soluble thiocyanate and if the well-known blood-red colouration develops the material is regarded with suspicion.

The writer is, however, of the opinion that such a test may lead to erroneous conclusions, since it has yet to be established whether iron can enter into chemical combination with one of the constituents of the jelutong and, if so, whether the iron in such combination is affected by treatment with acid and thiocyanate.

Further, since jelutong is prepared under such primitive conditions and contamination with iron is so easy it might happen that when testing the product in the manner described above the iron revealed by the test might be innocuous. Among the latter forms may be mentioned iron taken up by the material during refining either from the water or the iron vessel in which the treatment is carried out, also the press in which the blocks are shaped.

In the writer's opinion there is no doubt that if it were possible to persuade producers to use glazed earthenware pots or tin vessels free from rust for coagulation and to coagulate the latex with pure reagents oxidation in Malayan jelutong would be a negligible factor.

Compared with iron, the effect of copper is of minor importance since it is not present in latex and under normal circumstances it is not possible for copper to be present to the extent necessary to induce oxidation.

Soluble manganese salts added to the latex before coagulation are without action as regards oxidation, and it is also doubtful whether they produce abnormal mould development.

## 2. Kedah Latex.

In view of the differences found as regards the storage qualities of crude Kedah jelutong compared with the local product an investigation was made regarding the more important constituents of the latex similar to that carried out with latex from local forest reserves and described in this Journal, Vol. XV, 1927, No. 3, page 65.

Experiments regarding the amount of total solids obtained by evaporation, compared with that coagulated by alcohol, showed that for Kedah latex the excess of total solids obtained by evaporation is much less than in the case of local latex as the figures in the following table show:—

| | Local latex per cent. | Kedah latex per cent. |
|---|---|---|
| Total solids (dried at 100°C) ... | 19.87 | 21.34 |
| Total solids (on ignition) ... | 0.03 | 0.03 |
| Solids (coagulated by alcohol) ... | 15.54 | 18.94 |
| Nitrogen (Kjeldahl) ... ... | 0.025 | 0.026 |

The results indicate therefore that while with the local latex the excess solids, calculating the amount coagulated by alcohol as 100 per cent, amount to approximately 28 per cent there is an excess of only 13 per cent for Kedah latex.

A qualitative analysis of the residue left on ignition showed the presence as in local latex of varying quantities of calcium, magnesium, potassium, sodium, phosphate and carbonate.

Further, an approximate analysis of the solids not precipitated by alcohol showed the presence of constituents similar to those in local latex, namely sugars and gummy substances. The figures for both the nitrogen content of these solids and the amount of residue on ignition, calculated on a moisture-free basis, were also in close agreement with those found for local latex.

Duplicate experiments in which both acetic acid and sulphuric acid were used as coagulants showed that only in one instance was there any tendency for the crude material to develop deterioration due to mould, while the blocks refined by boiling with water showed no tendency to develop oxidation, even though stored for six months.

With regard to coagulation of the latex with alcohol experiments showed that there was no tendency for the product to develop oxidation on storage, even though the jelutong was creped before pressing into a block. The results obtained in the previous series of experiments as regards the tendency of the product when prepared in this manner to oxidise must therefore be regarded as abnormal.

Deterioration due to oxidation can be induced in the Kedah product by the addition of soluble iron to the latex before coagulation in the same proportion as found for local latex. Soluble copper and manganese salts added to the latex before coagulation have also similar effects on the resultant product.

## Remarks and Conclusions.

The investigation shows that there is no evidence in support of the statement that Kedah jelutong is particularly liable to oxidation.

The latex contains a smaller proportion of serum solids than local latex and the product is therefore less liable to develop deterioration due to mould.

As far as can be judged therefore the alleged tendency of this jelutong to oxidation can only be ascribed to a greater degree of contamination of the latex with soluble iron before coagulation.

### 3. The Storage Qualities of Creped Jelutong.

As stated previously this investigation was carried out in order to ascertain whether as a result of passing jelutong between rollers the creped material was liable to oxidation.

Sample blocks of refined Malayan jelutong from various producers were obtained through the kind agency of Messrs. L. A. Dreyfus & Co., Singapore, while additional blocks of refined material were prepared in the Department both from local latex and from Kedah latex. In the case of the local latex the material was prepared by coagulation by boiling, but with the Kedah latex the latter was coagulated with alcohol in order to obtain additional confirmation of the previous results obtained with this coagulant as regards oxidation.

The jelutong was passed three or four times between crepeing rollers, the material being then cut into short strips and stored in an airy cupboard.

The acetone soluble content of the material was determined at the commencement of the period of storage and afterwards at monthly intervals, or until the material was completely oxidised and fell to pieces.

It was found that when the material was passed between crepeing rollers a small amount of iron, amounting to approximately .01 grammes per 100 grammes of dry product, was taken up. In one experiment therefore the rollers were covered with a layer of thick canvas in order to eliminate this source of contamination. In the case of the samples from the various producers there was an excess of iron, indicating that the material had also been contaminated with this metal at an earlier stage of its preparation.

The results of the various experiments summarised in Table III show that while there are definite increases in the acetone soluble content of the material from Malayan producers, calculated on a moisture-free basis, the variations in the figures for the material prepared in the Department either from local or Kedah latex are negligible, being within the range of experimental error for such a determination.

### Remarks and Conclusions.

It appears therefore that in the case of the F. M. S. and Singapore refined jelutong the increased tendency to oxidation

## TABLE III.

*Results of Experiments showing Increases in Acetone Soluble Content of Creped Jelutong on Storage.*

(The results are expressed as percentages on the moisture-free material).

| Period of Storage. | F.M.S. Sample No. 1. | F.M.S. Sample No. 2. | Singapore Refined. | Forest Dept. Latex No. 1. | Forest Dept. Latex No. 2. | Kedah Latex coagulated with alcohol. | Kedah Latex coagulated with alcohol and rollers covered with canvas. |
|---|---|---|---|---|---|---|---|
| | per cent. | per cent. | per cent. | per cent. | per cent. | per cent. | per cent. |
| Fresh ... | 77.9 | 78.4 | 76.5 | 78.0 | 78.8 | 78.8 | 78.2 |
| 1 month ... | 78.7 | 85.5 | 90.8 | 79.3 | 80.2 | 78.0 | 78.3 |
| 2 months ... | 79.1 | 94.1 | 91.5 | 76.5 | 78.1 | 80.6 | 79.8 |
| 3 months ... | 81.5 | 95.2 | 92.4 | 79.0 | 78.7 | 77.7 | 78.5 |
| 4 months ... | 82.0 | Material fell to pieces. | Material fell to pieces. | 78.3 | 78.2 | 77.7 | 79.4 |
| 5 months ... | 85.6 | | | | | | |

cannot be due to the small amount of iron taken up during the crepeing process seeing that the material prepared from both local and Kedah latex is unaffected. Further, in the case of the samples of F.M.S. material it is more than likely that the latex was also obtained from Selangor forest reserves so that the possibility of variations in the constituents of the latex is also practically eliminated.

Support is therefore lent to the theory that oxidation is due to other causes and, since there is an excess of iron present, it is not improbable that sufficient of this metal was present in a soluble form in the latex before coagulation to permit of the development of oxidation.

## Summary.

The article describes certain experiments regarding the effect of the addition of certain metallic salts to jelutong at various stages of its preparation.

2. The results show that the addition of soluble iron in relatively small amounts to the latex before coagulation has a marked effect as regards inducing oxidation in the resultant product.

3. Experiments with Kedah latex show that there is no evidence in support of the statement that the product from that State is liable to oxidation.

4. A series of experiments carried out on the storage qualities of creped jelutong from various sources shows that the material in this form has no increased tendency to oxidation.

In conclusion the writer wishes to thank Mr. Gunn Lay Teik for his assistance in carrying out most of the analytical work in connection with the various investigations, also Messrs. L. A. Dreyfus & Co., Singapore, for their continued interest in the work and their kindness in providing the requisite samples for analysis.

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# System of Land Tenure in Kelantan.

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## Historical.

Prior to the reign of Sultan Mulut Merah land in Kelantan was disposed of by the local headmen (To' Kweng) on behalf of the Ruler. In 1881 a system of registration of changes of ownership was introduced and in 1896 a land office was inaugurated at Kota Bharu by direction of Sultan Mansur. During the period 1881 to 1915 a large number of titles in varying forms ("chop lama", "miliki" and the like) were issued, many of which are still extant. These are being replaced, as rapidly as circumstances permit, by titles under Grant or Entry in the Mukim Register. Lands granted under the old forms of title were not surveyed, the situation, boundaries and in some cases the approximate area being as a rule roughly indicated by a sketch on the margin or back of the title. Prior to 1916 no quit rent was collected, the occupier paying a produce tax (*hasil padi* or *hasil buah*) to the State which was collected by the local headmen. This form of land tax still survives in a few Mukims in the extreme north-west of the State (Kelantan Bharu) where survey and registration of title have not yet been completed.

## Land Law.

Up to the year 1926 the law governing the tenure of land in Kelantan was comprised in the Land Rules of 1914 and 1921 together with a large number of Notifications having the force of law which were promulgated at various times between 1910 and 1926. In 1926 a Land Enactment was passed and brought into force in August of that year, embodying the essential elements of land legislation according to the Torrens System. An amending Enactment introduced in 1928 has specifically repealed a large number of Notifica-

tions, which were either obsolete or conflicted with the principal Enactment. The 1926 Enactment was not designed to be the final expression of the land law of Kelantan and a comprehensive Land Code, based in the main on the Federated Malay States Land Code of 1926 with such modifications as local conditions may require, is now in course of preparation.

### Organisation.

For purposes of land administration the State is divided into three districts

(i) Kota Bharu, including the sub-district of Pasir Mas

(ii) Ulu Kelantan

(iii) Pasir Puteh, including the sub-district of Bachok.

Each District is in charge of a European District Officer, with Malay Assistant District Officers for the sub-districts of Pasir Mas and Bachok. The District Officer, Kota Bharu is, in addition, Registrar of Titles for the State. The District Officers and Assistant District Officers have under them one or more Malay Assistant Collectors of Land Revenue with similar legal powers. Districts are sub-divided into Daerahs, each under the control of a local headman known as a Penggawa. The Daerah again is subdivided into a number of Mukims. The Mukim is the unit for survey and land registration.

### Alienation and Methods of Tenure.

The following varieties of land are recognised by law: —

(a) Town Lands

(b) Country Lands under 10 acres in area

(c) Country Lands of 10 acres in area and upwards.

All land which is neither alienated nor reserved and on which no rent is paid to the State is deemed to be State Land.

*Town Land.* The document of title for town land is a Grant or a Lease of State Land, usually the former. A Grant conveys an absolute title in perpetuity subject to the payment of the annual quit rent and to the observance of the general

conditions implied in the Land Enactment and to any special conditions which are expressly set forth in the Grant. A lease conveys such rights and interests as are set forth in the document of lease and runs for a definite term of years prescribed in each case by His Highness the Sultan in Council. Alienation of town lands is usually carried out by auction, the sum due on account of premium, survey fees, cost of boundary stones and fees for preparation and registration of the document of title being included in the upset price.

*Country Lands under 10 acres in Area.* The title for land of this category is since the passing of the Land Enactment 1926, an entry in the Mukim Register, but the work of entering up old alienations in the Registers is still far from complete and a large number of old forms of title are still extant. In the absence of an Entry in the Mukim Register, the entry in the Settlement Index constitutes a temporary title pending the preparation of the Mukim Register. The Entry in the Mukim Register gives an absolute title to land and where survey, or revision survey, by theodolite has been completed an Extract from the Mukim Register, with a plan of the land as surveyed endorsed thereon, is issued to the registered owner.

*Country Lands of 10 acres in area and upwards.* The title for this class of land is a Grant or Lease of State Land, usually the former. The scale of premium and rent has recently been raised but provision is made for variation within wide limits according to the quality and accessibility of the land applied for and for specially favourable terms in respect of the cultivation of new agricultural products which it is desired to encourage.

## Applications for Land.

Applications for State Land should be addressed to the District Officer of the District in which the land is situated, and should be made in writing accompanied by a sketch map of the land applied for, together with full details as to the purpose for which the land is required. In the case of application for large areas an interview with the District Officer is advisable.

The legal authority for all alienation is His Highness the Sultan in Council, but power to alienate land of less than

10 acres in area is delegated, subject to certain restrictions, to the District Officers. The approval of an application is conveyed through the District Officer, who will inform the applicant of the amount to be paid or deposited by way of premium, survey fees and quit rent and will indicate the nature of the special condition, if any, imposed and the form of title under which the land is to be held.

Occupation prior to survey may be allowed with the permission of His Highness the Sultan or, in the case of areas under 10 acres, of the District Officer, provided all fees and dues are first paid or deposited and the boundaries of the land are marked out to the satisfaction of the District Officer, but such approval implies no claim on the part of the applicant to a greater area than that originally applied for.

On completion of survey and settlement of all fees and dues the District Officer will obtain the issue copy of the document of title from the Registrar of Titles and will deliver it to the applicant.

A precis of the Premium and Rent Rules, 1928, showing the scale of premia and rents now in force for the different categories of land, is given in Appendix A.

Quit Rent is payable on the 1st January in each year at the District Land Office, without demand. Any quit rent not paid by the 30th April is deemed to be an 'arrear' and is recoverable by process of law. Notices of Demand are issued and if not complied with by the 30th June the amount due is recoverable either by the attachment and sale of the moveable property of the defaulter or by attachment and sale of the land, or any part of it, in respect of which default of rent has been made. The District Officer may employ either of the above methods of recovery, at his discretion.

### Cultivation and Special Conditions.

The following extracts from the Land Enactment 1926 deal with the obligations imposed by law on the registered owner of country land in respect of cultivation:—

"Unless it is otherwise specifically provided by special condition endorsed on the original document of title or in the Mukim Register all alienated lands are subject to the following conditions respecting cultivation:

"(a) Where the title covers an area of more than fifty acres the land described therein shall be cultivated to the extent of not less than one tenth within one year from the date of registration of title and to the extent of one quarter within five years from the date of registration of title.

"(b) Where the title covers an area not exceeding fifty acres the land described therein shall be cultivated to the extent of not less than one quarter within one year of the date of registration of title and the whole within four years of the date of registration of title."

Any land may be alienated subject to such special conditions relative to buildings, cultivation or upkeep as His Highness the Sultan in Council (or, in the case of holdings less than 10 acres in extent, the District Officer) may see fit to impose.

Breach of special conditions or of cultivation conditions renders the land liable to forfeiture and resumption by the State.

## Surveys.

A Survey Department was organised in Kelantan in 1911, and between the years 1911 and 1926 virtually the whole of the occupied portion of the Kelantan coastal plain, comprising the majority of the Districts of Kota Bharu and Pasir Puteh and containing approximately 300,000 holdings, was surveyed by plane table. Concurrently with this survey Settlement Indices were prepared for each Mukim and Rent Rolls compiled. As the record of each Daerah was completed the collection of quit rent on acreage was substituted for that of produce tax. The record of occupation provided by the Settlement Index was recognised as evidence of a valid and transmissible title of land, pending the preparation of the Mukim Registers.

Concurrently with the progress of the plane table survey the survey by theodolite of town lands and of extensive areas of estate lands was carried out.

In 1926 it was decided that plane table survey should be discontinued and that all future survey should be carried out by theodolite. No title is now issued except after theodolite survey. The revision survey of the large areas of small hold-

ings surveyed by plane table prior to 1926 will be a task involving the expenditure of much time and money.

In the case of new applications for land of less than 10 acres in extent, the area is demarcated by the demarcation staff of the District Office, a lot number is assigned by the Survey Office after plotting on Survey Office maps and the holding entered in the Settlement Index and Rent Roll, the applicant being placed in immediate possession pending the fulfilment of the requisition for survey. An applicant for a larger area e.g. for estate cultivation, could ordinarily count on the completion of survey within a reasonable period, permission to occupy prior to survey being as a rule readily obtained.

The new scale of survey fees, which was brought into force in 1928, is given in Appendix B.

## Conclusion.

The coastal plain of Kelantan consists of a fertile alluvial area of approximately 1,000 square miles, roughly rectangular in shape, having a length of about 60 miles and an average breadth of 25 to 30 miles. Almost the whole of this area is intensively cultivated by a hardy and industrious peasantry; the population is of a remarkable density, being slightly over 230 persons to the square mile; the average size of the native holding is about one acre. This area comprises the bulk of the Districts of Kota Bharu and Pasir Puteh and within it there is little land left available for alienation, except such as is required to fulfil the constant demand for small holdings for native cultivation, and the unalienated area is steadily diminishing in extent. The total cultivable area available for alienation in Kota Bharu and Pasir Puteh Districts probably does not exceed 30,000 acres, of which a considerable proportion is in Kelantan Bharu, the extreme north-west portion of the State, and is consequently difficult of access.

The bulk of the European-owned estates are situated in the District of Ulu Kelantan and here there are large tracts of land available for alienation, the estimated extent of which is computed to be some 4,300 miles much of which, however,

is mountainous and difficult of access. The District is traversed by the road from Kota Bharu to Kuala Krai, the district headquarters, 53 miles from the coast, and by the Federated Malay States railway which is completed and open to traffic as far as Manek Urai, 8 miles beyond Kuala Krai. At a rough computation there may be said to be 300 to 500 square miles of cultivable land within reasonable distance of the road and the railway. The completion of the latter should stimulate the demand for land for estate cultivation in the interior of the State.

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# APPENDIX A.

## Precis of Premium and Rent Rules (Kelantan) 1928.

*I. Town Lands.*

(i) Alienation generally by auction. The reserve price on lands sold by auction and the premium payable in the case of lands not sold by auction to be fixed in each case by His Highness the Sultan in Council.

(ii) Annual rent to be such as is fixed in each case by His Highness the Sultan in Council, with the following minima:—

Building lots of 2,400 square feet or less, per lot $2.00.

Building lots of more than 2,400 square feet, at the rate of $2 for every 2,400 square feet or part thereof.

Town lands (other than building lots), $5 per acre.

*II. Country Lands.*

(A) Premium:—

(i) On Country Lands (a) of less than 10 acres in area and (b) between 10 and 20 acres in area:—

Rice land, $5 to $15 per acre.
Kampong land, $10 to $15 per acre.
Rubber land, $15 to $25 per acre.

(ii) On Country Lands of 20 acres in area and over:—

If the cultivation of rubber is prohibited, not less than $10 nor more than $25 per acre; if the cultivation of rubber is not prohibited, not less than $20 nor more than $50 per acre.

Notwithstanding the above, His Highness the Sultan in Council may fix special rates in special cases.

(B) Annual Rent:—

(i) On Country Lands of ten acres in area and over: One dollar per acre per annum for the first six years and thereafter three dollars per acre per annum.

(ii) On Country Lands of less than ten acres in area:
Rice land, $0.40 to $1.
Kampong land, $0.80 to $1.60 cents.
Rubber land, $1.20 cents to $1.40 cents.

## APPENDIX B.

### Survey Fees.

A. In the case of agricultural land of less than 10 acres in area held and to be held by Entry in the Mukim Register the cost of survey fees and boundary marks shall be included in the premium charged.

B. In all other cases, except those Town Lands for which special rates are allowed under rule C, the following shall be the fees prescribed for survey:—

| | |
|---|---|
| 5 acres and under ... | $25.00 |
| For each additional acre up to 10 acres | 4.00 |
| 10 acres ... | $45.00 |
| For each additional acre up to 25 acres | 3.00 |
| 25 acres ... | $90.00 |
| For each additional acre up to 50 acres | 2.00 |
| 50 acres ... | $150.00 |
| For each additional acre up to 100 acres | 2.00 |
| 100 acres ... | $250.00 |
| For each additional acre up to 200 acres | 1.00 |
| 200 acres ... | $350.00 |
| For each additional acre up to 300 acres | .90 |
| 300 acres ... | $440.00 |
| For each additional acre up to 500 acres | .80 |
| 500 acres ... | $600.00 |
| For each additional acre up to 1,000 acres | .70 |
| 1,000 acres ... | $950.00 |
| For each additional acre above 1,000 acres | .60 |

C. For town lands the fees prescribed shall be:—

| | |
|---|---|
| For lots not exceeding 2,400 square feet in area, per lot ... | $10.00 |
| For lots exceeding 2,400 square feet but less than one acre in area, per lot ... | $15.00 |
| For lots exceeding one acre in area the fees prescribed in Rule B. | |

# Chemical Investigations on Coconuts and Oil Palm.

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*The following article is based on a paper read by the writer at the Bagan Datoh Club, Lower Perak, on April 4th 1929.*

## Introductory.

Apart from rubber and from the point of view of estate agricultural practice the two most important crops at present being cultivated in Malaya are coconuts and oil palm. It is only reasonable therefore that these crops should be made the subjects of special investigations as far as the Department of Agriculture is concerned.

There is no need to emphasise the importance of coconuts either from the point of view of general cultivation or of an estate crop. The latest returns show that at present approximately 168,000 acres are planted with coconuts in the Federated Malay States, approximately 60,000 acres being under European management. In the case of oil palms, that have only become established as a major crop during the past few years, there are in Malaya approximately 24,000 acres already planted together with a further 27,000 acres of reserve land not planted or in course of planting, while other large areas of land have also been reserved provisionally for this crop.

Both coconuts and oil palm have their own special lines of chemical investigation, and in this paper I shall endeavour to outline briefly those points with which the Chemical Division is at present more especially concerned. In this connection I hope that you will not be disappointed if I devote rather more of my time to a consideration of the chemical problems connected with oil palm. The reason is chiefly personal, for, while I have been working for the past two years on oil palm products, it is only recently that I commenced any coconut investigations. Further, those of you who have

studied the oil palm industry or visited oil palm factories will realise the importance of the many chemical problems connected with the preparation of high quality oil palm products. The oil palm factory marks the commencement of what may be termed technical estate practice. Compared with coconuts, oil palms are not an easy crop and the estate manager, unless he is so fortunate as to serve on an estate large enough to enable him to devote himself to field work and to allow of the employment of a separate manager for the factory, will find it necessary to pay special attention to the factory process if he wishes to maintain a high quality of products.

I think there is every reason to believe that under suitable conditions oil palms will prove on the average a more remunerative proposition than coconuts, although in the case of the former crop the initial outlay is heavier on account of the relatively large factory capital charges, which amount to approximately £5—£6 per acre.

The necessity for such a relatively heavy outlay is explained by the fact that the more valuable constituent of the fruit, palm oil, must be recovered with the least possible delay after harvesting if high quality oil is to be produced.

## Coconuts.

The principal investigation being carried out at present in the Division is the establishment of standards for the oil content of Malayan Estate copra.

Reports have recently been received from London that the value of Straits copra is tending to deteriorate owing to a reduction in oil content and statements have been made that whereas Straits copra formerly had an oil content of 66/67 per cent of oil and yielded 63/64 per cent of oil, recent shipments had been found to contain only 63/64 per cent of oil yielding only 60/61 per cent of oil. The establishment of standards for Estate copra appears desirable, especially in view of the fact that before export Estate copra is sometimes mixed with native copra, the latter being frequently inferior both in quality and oil content.

Six estates distributed throughout Malaya are therefore forwarding during a period of six months regular monthly

samples of their copra. These samples, amounting to approximately 5 lbs., are analysed and the results reported to the individual estates. In due course a summary of the results of the investigation, in which the estates will be referred to by letter or number, will be published in this Journal.

It may be of interest to you to know that the variations in the 17 samples examined to-date are as follows:—

| | Maximum per cent. | Minimum per cent. | Average per cent. |
|---|---|---|---|
| Moisture ... | 8.2 | 4.7 | 6.4 |
| Oil (on sample as received) | 62.9 | 57.7 | 60.6 |
| Oil (on moisture-free basis) | 66.9 | 62.3 | 64.7 |

The comparatively wide variations in moisture content are interesting and point to the necessity of an investigation into the most economical method of drying the fresh meat.

If we divide the figures for the oil content of the copra, calculated on a moisture-free basis, into three groups, 62—64 per cent, 64—66 per cent and 66—68 per cent we find that of the 17 samples examined four fall in the first group, eleven in the second group and two in the third group. This indicates therefore that apart from seasonal variation the present oil content of estate copra, calculated on a moisture-free basis, probably lies within the limits 64—66 per cent.

Although the investigation has only been proceeding for about two months it appears probable that the full results will be in agreement with those obtained to date. All the same I hope that those who are interested in the subject will study the summary of the whole investigation.

As a result of this work the next step will be to decide whether it is not possible either to improve the oil content of the copra from present palms or to breed other palms having a higher oil content.

The reason for the relatively low oil content is difficult to explain and may be due to one or other of a variety of causes, probably a combination of causes. Among the reasons that suggest themselves are the climate, the state of ripeness of the

nuts when picked, a low yielding strain, lack of cultivation, unsatisfactory drainage and unsuitable soil conditions.

As regards the first possibility it is well known that on account of the equable and moist climate of Malaya there is rapid germination of the ripe nuts even while still on the palms, particularly as many estates do not pick at intervals of less than two months. An examination of the piles of nuts on estates shows quite a material percentage of germinations. There is little doubt also that the meat of a germinated nut is slightly deficient in oil content owing to the enzyme action produced by germination.

This question would point therefore to a problem in economics as to whether it would not be preferable to pick at shorter intervals if such a procedure produced copra of higher oil content.

Experience with oil palms has shown that the state of ripeness of the fruit has a direct effect on the oil content of the pericarp, and it is probable that the oil content of the coconut is affected in a similar manner.

Variations in many characters exist in all crops and it is certain that the coconut is no exception to this rule. The question of variation in coconuts as regards fruiting qualities is already engaging the attention of the Department, particularly the Botanical Division, and it has been found that the coefficient of variation in the number of nuts produced per annum is as high as 34 per cent of the mean production per palm under average estate conditions. The study of variation has also revealed the fact that 19 per cent of the palms on the average estate are unprofitable. Fruiting characters of individual palms have been found to be definitely constant over a period of 8 years and no doubt this constancy also exists as regards the oil content of copra from individual palms within the range of seasonal variation. This latter investigation is already in hand and although approximately 400 samples of copra have already been analysed this number is scarcely sufficient to overcome the effect of seasonal variation.

## Oil Palm.

Before dealing with the various points of chemical interest as regards the preparation of oil palm products and illus-

trating the necessity of chemical control it would be advisable to give the average composition of the fresh fruit and also to outline briefly the method of factory treatment. As regards the latter I hope that the sheets, which have already been handed round and on which the process is shown diagrammatically, will be of value in helping you to follow the various stages of the treatment.

The following table gives the approximate composition of fresh oil palm fruit:—

| | | Per cent. |
|---|---|---|
| Pericarp | | 57—60 |
| Nut | | 40—43 |
| Pericarp | Moisture | 36—40 |
| | Oil | 47—51 |
| | Residue | 14—16 |
| Nuts | Shell | 78—82 |
| | Kernel | 18—22 |
| Palm oil (calculated on fresh fruit) | | 29—30 |
| Kernel (calculated on fresh fruit) | | 7— 8 |

The above figures, which refer to the fully developed fresh ripe fruits, can only be regarded as approximate since experiments show that it is difficult to select average samples of fruit from a consignment. The problem of selection of average material for analysis becomes even more difficult when a bunch of fruit is considered, since the latter contains fruits in all stages of development and therefore of varying oil contents.

Analysis of the fruit from the point of view of oil content is therefore not usually attempted directly, the oil content of the bunch or of the fresh fruit being calculated indirectly. The amounts of oil lost at various stages of the process are estimated and by adding these amounts to that

of the oil recovered measures of both the oil content of the bunch or the fruit and also of the efficiency of the process are obtained.

As regards the treatment of fruit the latest process consists in the sterilisation of the bunches with steam under pressure. The bunches are then stripped, the sterilised fruit being transferred to a digester in which the fruit is mashed or pulped. The bulk of the pericarp oil, approximately 85 per cent, is then removed either by pressing or centrifuging the pulped mass. Both methods of treatment of the mash have been included in the diagram since they are both used in practice, the press system being favoured in Sumatra, while the centrifugal system has been adopted in this country.

At this point in the treatment there are two intermediate products, crude palm oil and a mass consisting of nuts and pericarp residue.

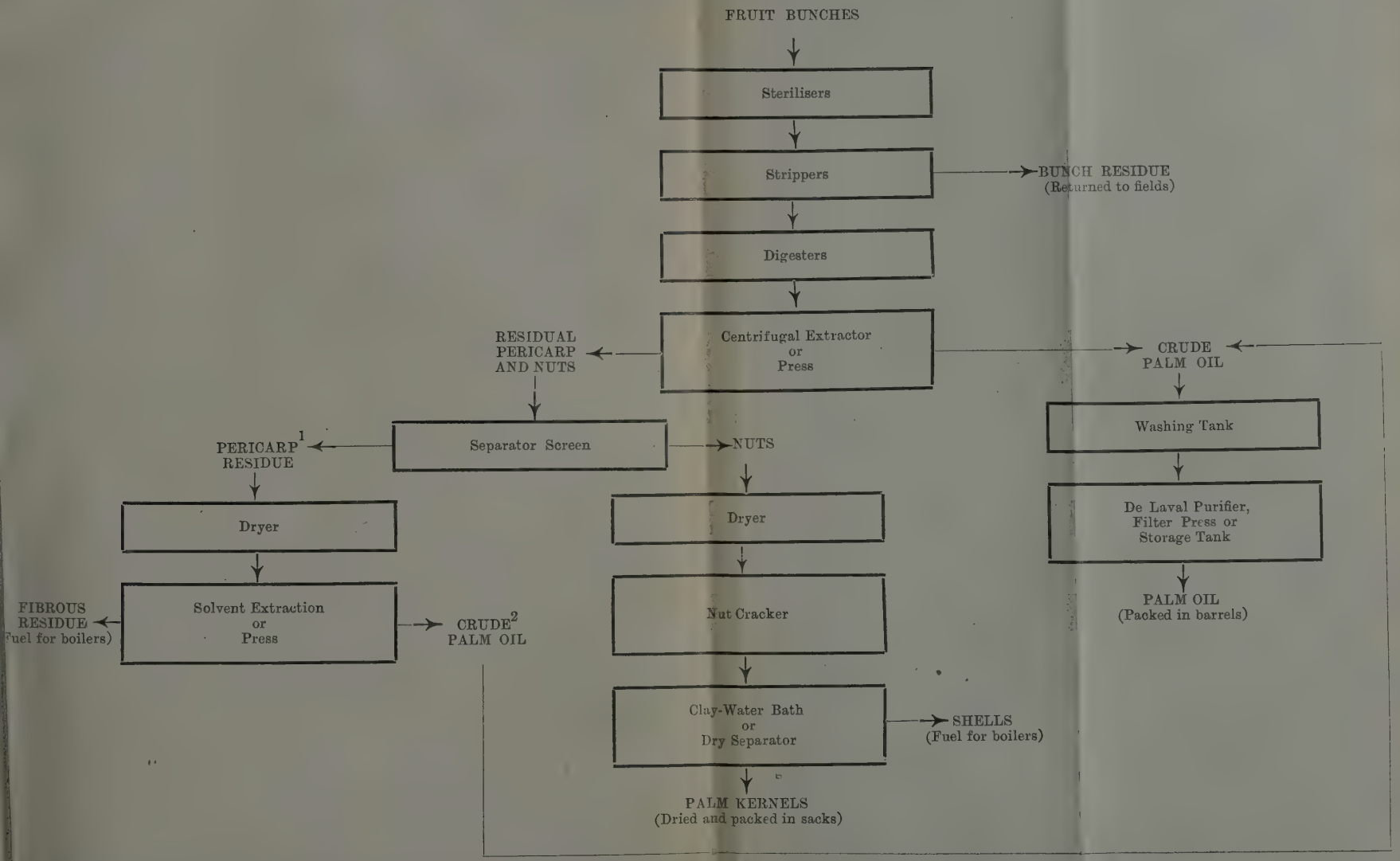
The crude oil is purified by agitation with live steam, after which it is allowed to stand and the almost clear supernatant oil transferred to a storage tank for a further period of settling or the oil can be purified by passing direct from the washing tank through either a centrifugal separator of the De Laval type or through a filter press. The oil is then packed in barrels for export.

The mass of nuts and residual pericarp is screened in order to separate the material into its constituent parts, the nuts being dried and cracked in a nut cracker, usually of the centrifugal type. The broken shells and kernels are separated in a suspension of clay in water, although there is little doubt that ultimately a dry method of separation will be evolved. The machine will work on the principle that kernels owing to their more rounded shape tend to roll faster than the broken particles of shells on an inclined plane moving in the opposite direction.

The kernels, which still contain from 10 to 12 per cent of moisture, are further dried before packing in sacks for export.

Although the details of the treatment of the pericarp residue have been included in the diagram the present prac-

## DIAGRAM SHOWING FACTORY PROCESS FOR TREATMENT OF OIL PALM FRUIT




1. The subsidiary treatment of the pericarp residue is not at present practised in Malaya, the pericarp residue from the separator screen being used as fuel.
2. When high grade oil is being prepared it may be advisable to treat the crude palm oil from the second pressing or solvent extraction in a separate installation and market as second grade oil.

tice in Malaya is merely to use this material as fuel. Experience in Sumatra, where the oil palm industry is developed to a much greater extent than in Malaya, has shown that the subsidiary treatment of the residue, either by second pressing or solvent extraction, is only an economical proposition for large estates, 3,000 acres and upwards in full bearing, on which there is sufficient residue to maintain a plant in continuous operation.

Both the second pressing and solvent extraction method are in use in Sumatra. As regards recovery of oil the latter method has the advantage, since it is possible to recover practically the whole of the oil in the pericarp residue, including that on the surface of the nuts, by treatment with solvent. With the second pressing approximately only half the remainder of the oil in the pericarp residue is obtained, the total recovery of oil with two pressings amounting to approximately 92 per cent.

Mention might be made here of a process that is being developed for the treatment of the whole fruit by solvent extraction. Undoubtedly this is an ideal method of treating the fruit, since the whole of the oil can be recovered in a single operation. There are, however, difficulties to be overcome, among which may be mentioned the losses of solvent and the relatively high moisture content of the fruit. The latter would necessitate the removal of a very large amount of water from the digested mash in order to obtain the maximum effect of the solvent, also there is the possibility of some of the mucilaginous matter present in the fruit dissolving in the oil, thereby affecting its storage qualities. It is quite possible, however, that such a method may eventually be employed, although at first sight it appears preferable to recover the greater part of the oil by a simple process of pressing or centrifugal extraction and then the remainder of the oil by solvent extraction.

Although the factory process may appear complicated it is in reality only a sequence of simple operations, the whole process being designed to secure the maximum yield of high quality products with the minimum amount of manual labour.

The entry of Sumatra and more recently Malaya with their well-established estate organisation methods into the oil palm industry is resulting in the production of increasing

quantities of high grade oil palm products, particularly palm oil of a low acidity. Up to a few years ago the whole of the world's supply of oil palm products came from West Africa, the bulk of the palm oil being of a much inferior grade to that produced under estate conditions owing to the primitive methods of preparation of the oil. Unless therefore the average quality of the West African oil is greatly improved it is unlikely that for several years to come plantation palm oil will compete to any extent with the West African product, since it is anticipated that plantation palm oil will be used to meet the ever-increasing demand for high grade oils and fats for edible purposes as soon as large and regular supplies of the oil are forthcoming.

It will be realised that with such a technical process chemical control is a necessity, firstly since the value and application of the principal product in the industry is so largely affected by its acidity and secondly that with such a high capital outlay on plant it is important to ensure that maximum yields of products are being obtained.

The greater part of the chemical work on oil palm during the past two years has therefore been concerned with the factory side of the crop, although there is one investigation now in progress to which attention might be drawn, namely the removal of plant nutrients from the soil by the palm. It is realised that with the relatively large numbers of fruit bunches harvested annually artificial manures will have to be employed to maintain yields and a knowledge of the amount of plant nutrients removed in this way will be of some assistance when arranging details of manurial experiments.

As mentioned previously chemical control in an oil palm factory begins directly the bunches of fruit are weighed since a low yield of oil is frequently due to the bunches being picked slightly unripe. In order to obtain the maximum production of oil it is essential not to harvest the fruit bunch until ripe, as it has been definitely established that when a bunch of fruit is harvested the process of ripening ceases as far as the development of oil in the pericarp is concerned. The increase in oil content found with fruit stored for a few days before treatment is merely due to a decrease in the moisture content of the pericarp resulting in an apparent increase in the oil content. In order therefore to obtain comparable results it is essential that the procedure on an estate

should not vary and from that point of view the process of dealing with fresh bunches has much to recommend it, since direct comparisons between the weight of fresh bunches harvested and the weights of products recovered can be obtained.

Although the method of sterilising bunches requires an efficient transport system on the estate the method has the great advantage of dispensing with collecting sheds, thereby saving labour in the field. Further, since the fruit is not bruised to the same extent as when separated in the field, it is possible to produce an oil of lower acidity.

The acidity of the oil produced in an estate factory from fruit previously separated in collecting sheds varies from 3 to 4 per cent, calculated as palmitic acid, but by sterilising the bunches the acidity of the oil can be reduced to between 2 and 3 per cent, so that it is possible to guarantee the acidity of oil on arrival in Europe to be less than say 3.5 per cent. If fruit be sterilised immediately after harvesting it is possible to recover oil with an acidity of only 0.5 per cent so that the increase of say 1.5 per cent in the case of the bunches and 2.5 per cent in that of the fruit is due to the bruising of the fruit during transport from field to factory.

Slightly increased yields of oil are obtained as a result of sterilising the bunches under pressure owing to the coagulation of the gummy and albuminoid matters present in the fruit not affecting the extraction of the oil.

Our chemical investigations have shown that with the centrifugal system better results are obtained with a closed type digester working under slight steam pressure (Manlove Alliott type) than with a digester of the open kettle type. In the latter the mash becomes too thick and does not yield its oil so readily during the process of centrifugal extraction.

It is not proposed to discuss the merits of presses and centrifuges except to state that as regards the treatment of the whole fruit, and judged by the oil content of the pericarp residue, similar results are obtained by the two systems. From the point of view of cost the press is somewhat cheaper than the centrifuge, because the unit capacity of the latter is greater than the former but when a large installation, comprising several presses or centrifuges, has to be considered the difference is reduced considerably.

I have no experience of the purification of oil from presses, but the centrifugal system yields a crude oil that contains only relatively small proportions of sludge and moisture and is therefore easily purified in the manner already described.

During the past year between 50 and 60 samples of oil from various estates in Malaya have been examined and in no case has the dirt (matter in suspension) been found to exceed 0.02 per cent, rarely 0.01 per cent. The moisture figure has been found to vary from 0.15 to 0.45 per cent.

Palm oil increases in acidity on storage, the rate of increase varying with the amounts of moisture and matter in suspension. The latter consists of cellular debris and traces of mucilaginous matter and should therefore be reduced to a minimum.

Experiments have recently been carried out with a De Laval separator and the results show that, although the moisture content of the oil can be reduced to approximately 0.10—0.15 per cent, it is not always possible to remove the small amount of matter in suspension in the oil. In order to effect this successfully the oil would have to be heated to a temperature slightly exceeding 100°C in order to effect coagulation when separation would be a simple matter. One factor in favour of a De Laval separator is, however, the elimination of the personal element as regards the possibility of any sludge becoming mixed with the oil and, if the oil is to be used for edible purposes, the installation of such a machine on a large estate is recommended.

The average quality of Malayan estate palm oil, commencing with fresh fruit as the initial material in the factory, is as follows:—

| | Per cent. |
|---|---|
| Acidity (calculated as palmitic acid) ... | 3.0 —4.0 |
| Moisture ... | 0.25—0.35 |
| Matter in suspension ... | nil—0.01 |

The increase in acidity of oil of this quality is approximately 0.1 per cent per month so that by determining the

acidity of the freshly prepared oil it is possible to estimate with a fair degree of the accuracy the acidity of the oil on arrival at its destination. The determination of acidity of palm oil in a modified form is therefore part of the routine in all oil palm factories.

Although strictly speaking the subject does not fall within the scope of this paper I should like to mention the question of shipment of oil. At present barrels are used exclusively, the cost is heavy, amounting to $1\frac{3}{4}$ cents per lb. of oil. This sum represents a considerable proportion of the total cost of production. Although it is certain that from the point of view of small consumers shipment in barrels will always be required it is more than probable that in a few years time bulk shipments of oil will be made. Such a method would require a separate organisation, since it would not be possible for any particular estate to incur the large capital expenditure necessary. In view of the developments in Sumatra as regards this method of shipment and of the far-reaching benefits that would have resulted had other industries organised themselves in the past it is a matter for consideration whether some kind of oil palm organisation should not be started in order to keep abreast of the development of the industry. There is no doubt that there will be competition in the future in the oil palm products market and it seems advisable therefore to make preparations against this contingency.

In this connection both in view of the technical nature of the factory process and the necessity of chemical control the installation of small chemical laboratories for large estates or groups of smaller estates, in which routine analyses such as those indicated above can be carried out, is recommended.

The subsidiary treatment of the nuts and pericarp residue calls for little comment except to state that the separation of the material from the centrifugal extractor can be effected without previous drying. From the chemical point of view the analysis of the fibrous residue is important, since it gives an indication as to whether the digester and centrifugal extractor are working satisfactorily.

Since kernels are sold on their oil content as received at their destination it is essential to ship them as dry and as

clean as possible, although owing to the humidity of the atmosphere in Malaya it is impossible to avoid small losses in weight during transit owing to evaporation of moisture.

## Conclusion.

Such therefore is a brief outline of the more important chemical investigations at present being carried out with coconuts and oil palm. As you will realise much still remains to be achieved before our aims are reached, especially as regards the oil palm industry, which is still in its infancy as far as Malaya is concerned. It is however only by close co-operation between planters, scientific officers and manufacturers that the desired results can be obtained and in this connection I should like to impress upon you all that the Department of Agriculture is keenly interested in these two crops, the development of which is bound to contribute materially to a broadening of the basis of Malayan agricultural practice.

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